

AMENDMENTS TO THE DRAWINGS:

Please find accompanying this response replacement sheets for Figs. 3 and 4 wherein amendments explained in the Remarks presented below are effected.

REMARKS

Claims 1-14 remain pending in this application. Claims 1-14 are rejected. Claims 12 and 13 are objected to. Claims 1-6 and 9-14 are amended herein to address formal matters that were not addressed by the Examiner and accordingly are considered unrelated to substantive patentability issues. An appendix containing clean copies of the amended claims is provided for the Examiner's convenience.

DRAWING OBJECTIONS

The drawings are objected to. The Office Action states that Figs. 3 and 4 are too dark. Replacement sheets of Figs. 3 and 4 are provided herewith. The replacement drawings have the photographs presented in Figs. 3 and 4 lightened to the extent possible while still permitting accurate image interpretation. It is believed that these images provide the best possible reproduction of the images produced by the present invention. Withdrawal of drawing objection is respectfully requested.

CLAIM OBJECTIONS

Claims 12 and 13 are objected to due to misspellings. The claims are amended to address the misspellings. Accordingly withdrawal of the objections is respectfully requested.

CLAIM REJECTIONS UNDER 35 U.S.C. § 102(b)

Claims 1-6, 9 and 10 are rejected under 35 U.S.C. § 102(b) as being anticipated by the McDowell reference. Applicant herein respectfully traverses these rejections. "Anticipation requires the presence in a single prior art reference disclosure of each and every element of the claimed invention, *arranged as in the claim.*" *Lindemann Maschinenfabrik GmbH v. American Hoist & Derrick Co.*, 221 USPQ 481, 485 (Fed. Cir. 1984) (emphasis added). It is respectfully submitted that the cited reference is deficient with regard to the following.

Claim 1 recites the following method features which are not taught by the Mc Dowell reference:

determining point correspondences between the two cameras by measuring a displacement of respective interrogation areas in the first and second images using optical cross-correlation; and
determining the imaging equation by means of an approximation method, using known internal and external camera parameters and the point correspondences and the displacement of respective interrogation areas.

It is believed that a brief review of the present invention and what is disclosed in the background section of the present invention disclosure would be beneficial at this juncture in order to provide an appreciation of the distinguishing features of the present invention. The introduction of the specification describes what a PIV method is and what a stereo PIV method is. The PIV and stereo PIV methods are

distinguished from one another in that in the PIV method the camera is oriented on one illuminated section, while in the stereo PIV method, the illuminated section can be observed with at least two cameras from two different angles, and thus all three components of the velocity field can be determined. That is, the reason for the stereo PIV method is to measure two- and three-dimensional velocity fields.

Before measurements of a velocity field using a PIV, stereo PIV, or even 3D PTV method can be effected, a calibration must first take place, i.e., the position of the cameras relative to the plane of the illuminated section is determined, which is ultimately obtained by establishing the imaging equation. The imaging equation can be established using a so-called "calibration plate", and knowing the absolute position in space of the two cameras or using the calibration plate, the angle, and the orientation of the cameras relative to said calibration plate and the spacing between the cameras and the calibration plate, or using a calibration plate that is captured by the cameras in two or more positions. Moreover, there is also a so-called "three-dimensional calibration plate" for determining the imaging equation, such a three-dimensional calibration plate having two planes with corresponding markings at a fixed distance.

The aspect of the present inventive method relates to the fact that this inventive method for determining an imaging equation for the self-calibration is

optionally added to such a preceding calibration process, however it was performed.

This means that, for instance, the calibration using a plate represents the precursor to the inventive method for determining the imaging equation for the self-calibration.

The present inventive method provides determination of the imaging equation significantly more precisely with respect to performing for instance PIV or even stereo PIV methods. The steps that are to be performed individually are presented in the wording of the claim 1. Claim 1 provides for “determining point correspondences between the two cameras by measuring a displacement of respective interrogation areas in the first and second images using optical cross-correlation..”

Once the displacement is measured for the interrogation areas the imaging equation can then be determined. This is related in claim1 as “determining the imaging equation by means of an approximation method, using known internal and external camera parameters and the point correspondences and the displacement of respective interrogation areas.” The imaging equation can then be used for performing the PIV or the stereo PIV method or the 3D PTV method. The present invention thus uses point correspondence, interrogation areas, and cross-correlation to provide the imaging equation.

The Examiner cites column 3, lines 27 through 39 apparently merely because the word “correspondence” is used in relation to tracer particle tracks. However, this usage is “for a correspondence of individual particles over time.” It does not suggest the aforementioned displacement of interrogation areas, and cross-correlation to provide the imaging equation.

The McDowell in column 7, lines 46 and onward, references calibration. What results from the content of this paragraph is that the calibration there occurs using a so-called calibration plate as is described in the specification for the present invention on page 2. In line 50, again, it is stated that after the calibration, then the absolute coordinates of a particle in a flow can be determined, and specifically using the pixel positions of the particle on the two cameras. Determining the point correspondences between two cameras by measuring the displacement of the interrogation fields in the camera images by means of optical cross-correlation is not disclosed nor suggested by this reference. That the calibration actually occurs using a calibration plate can actually be taken from the wording of claim 7 of the citation, specifically in that a “calibration target plane” is mentioned there.

The reference by the Examiner to column 3, starting on line 25, does not change this at all, since there it is merely described how using the 3D PTV method

the speed of a particle in a fluid can be determined. In the 3D PTV method, a particle is observed in a volume from different directions by two or more or more cameras. The position of the particle in space is determined by means of triangulation, as is described in claim 1 of the McDowell reference, last paragraph. The determination of the location of the particle at two different times then results in the displacement of the velocity field, i.e. the velocity of the flow. Performing this method presupposes a calibration process, but does not replace it. Thus, as stated in the foregoing, the reference by the Examiner to column 3, starting on line 25, is not relevant because it does not describe the calibration as a precursor to a PIV method, stereo PIV method, or 3D PTV method.

It was stated that, for increasing the precision, the inventive calibration method is optionally added additionally after a calibration that has already been performed. However, there is the option of using the inventive calibration method for directly for calibration and not as a "second stage," as has already been described in the specification of the invention.

In view of the above, it is respectfully submitted that claims 1-6, 9 and 10 particularly describe and distinctly claim elements not disclosed in the cited reference, i.e., the reference does not suggest the aforementioned displacement of interrogation areas, and cross-correlation to provide the imaging equation..

Therefore, reconsideration of the rejections of claims 1-6, 9 and 10 and their allowance are respectfully requested.

CLAIM REJECTIONS UNDER 35 U.S.C. §103(a)

Claims 7 and 8 are rejected as obvious over the McDowell reference in view of the Meng and Hu article under 35 U.S.C. §103(a). Claims 11 and 14 are rejected as obvious over the McDowell reference in view of the Raffel reference under 35 U.S.C. §103(a). Claims 12 and 13 are rejected as obvious over the McDowell reference in view of the Walker article under 35 U.S.C. §103(a). The applicant herein respectfully traverses these rejections. For a rejection under 35 U.S.C. §103(a) to be sustained, the differences between the features of the combined references and the present invention must be obvious to one skilled in the art.

It is respectfully submitted that the proffered combination of references cannot render the rejected claims obvious because the secondary references does not provide the teaching noted above with respect to the anticipation rejection that is absent from the primary McDowell reference. Thus, the combination of prior art references fails to teach or suggest all the claim limitations.

In the Walker article, "Two-axis Scheimpflug focusing for particle image velocimetry," the problem of calibration is not addressed, only the use of a PIV

or stereo PIV method. The Raffel reference is directed to a PIV method with only one camera, and there is no reference to calibration in this reference.

Thus, it is respectfully submitted that the rejected claims are not obvious in view of the cited references for the reasons stated above. Reconsideration of the rejection of the claims 7, 8 and 11-14 and their allowance are respectfully requested.

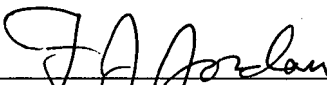
REQUEST FOR EXTENSION OF TIME

Applicant respectfully requests one month extension of time for responding to the Office Action. The fee of \$60.00 for the extension is authorized to be charged to Deposit Account No. 10-1250.

If there is any discrepancy between the fee(s) due and the fee payment authorized the USPTO is hereby authorized to charge any fee(s) or fee(s) deficiency or credit any excess payment to Deposit Account No. 10-1250.

In light of the foregoing, the application is now believed to be in proper form
for allowance of all claims and notice to that effect is earnestly solicited.

Respectfully submitted,
JORDAN AND HAMBURG LLP

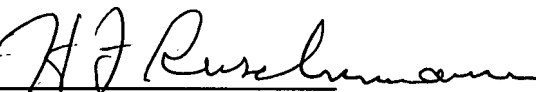
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enc: Replacement and Annotated drawing sheets of Figs. 3 and 4.



APPENDIX I

ALL PENDING CLAIMS WITH AMENDMENTS EFFECTED THEREIN

1. (Currently Amended) A method for determining the imaging equation for self calibration with regard to performing stereo-PIV methods on visualized flows, said method being comprised of:

providing at least two cameras and one image sector, with the cameras viewing approximately a same area of an illuminated section but from different directions;

taking first and second images simultaneously using respectively first and second camera of the two cameras, the first and second images respectively having corresponding interrogation areas;

determining point correspondences between the two cameras by measuring a displacement of respective interrogation areas in the first and second images using optical cross-correlation; and

determining the imaging equation by means of an approximation method, using known internal and external camera parameter and the point correspondences and the displacement of respective interrogation areas and the point correspondences and the displacement of respective interrogation areas.

2. (Currently Amended) The method according to claim 1, wherein the internal camera parameters include focal length, position of optical axes (x_0 , y_0) and distortion parameters of camera optics.

3. (Currently Amended) The method according to claim 1, wherein the external parameters include position and orientation of the cameras relative to each other.

4. (Currently Amended) The method according to claim 1, wherein if position of the illuminated section relative to a coordinate system of a known imaging equation is unknown, the position of the illuminated section is determined using the point correspondences.

5. (Currently Amended) The method according to claim 1, wherein if one or several of the internal camera parameters are known, other ones of the internal and external camera parameters are determined using the point correspondences in order to thus determine the imaging equation.

6. (Currently Amended) The method according to claim 1, further comprising:

taking two or more camera images respectively by the at least two cameras at sequential times t_0 to t_n ,

determining a two-dimensional correlation function $c_0(dx, dy)$ to $c_n(dx, dy)$ by means of optical cross-correlation at each time t_0 to t_n using corresponding ones of the images,

adding up the correlation functions c_0 to c_n ,

determining correlation peaks and a highest correlation peak, and

determining the displacement dx , dy of the respective one of the interrogation areas and, as a result thereof, the point correspondences being determined after based on the determination of the highest correlation peak.

7. (Previously Presented) The method according to claim 1, wherein the approximation method is based on the Levenberg-Marquardt algorithm.

8. (Previously Presented) The method according to claim 7, wherein the RANSAC algorithm is superimposed on the Levenberg-Marquardt algorithm.

9. (Currently Amended) The method according to claim 1, wherein each of the two cameras takes in short succession two images and that additional point

correspondences are determined using a cross-correlation between the images at the times t and $t + dt$.

10. (Currently Amended) The method according to claim 1, wherein optical axes of the at least two cameras are disposed coplanar to each other.

11. (Currently Amended) The method according to claim 6, wherein a section thickness of illuminated sections corresponding to respective timings of the images is determined through a width of the correlation peaks and a geometrical factor and that, together with the position of the illuminated sections in space, said thickness serves to determine an overlap between the illuminated sections and whether they are suited for PIV measurement.

12. (Currently Amended) The method according to claim 5, wherein with assumption of focusing on the particles in the illuminated section during the approximation method, an image width is calculated as a function of focal length of objectives of the two cameras and of a spacing between the illuminated section and the two cameras and needs not be fitted as a result thereof.

13. (Currently Amended) The method according to claim 5, wherein if a Scheimpflug adapter is used and with assumption that said Scheimpflug adapter is optimally adjusted, an angle between a camera chip and a main axis and a position of a principal point on the camera chip are computed from the external image parameters and need not be fitted as a result thereof.

14. (Currently Amended) The method according to claim 6, wherein section thickness of the illuminated sections is determined through widths of the correlation peaks and image geometry and that, together with the positions of the illuminated sections in space, said section thickness serves to determine an overlap between the illuminated sections and whether they are suited for PIV measurement.